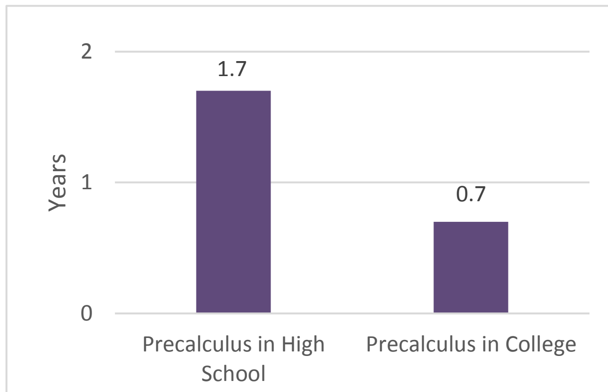
Effects of Elapsed Time between Precalculus and Calculus on Calculus Grades

UTAH EDUCATION POLICY CENTER
THE UNIVERSITY OF UTAH

November 2015

This research brief is third in a series of UEPC studies that explore post-secondary math education in Utah as part of the pipeline into STEM fields. The first study (and replication) found that students who enrolled in College Algebra (Math 1050) in high school through Concurrent Enrollment were significantly more likely to earn credit in College Algebra than students who enrolled in the same class in college. The second study compared students who passed Math 1050 and Math 1060 (which are together considered Precalculus) while in either high school or college, and found the two groups performed essentially the same in Calculus courses taken in college. However, the second study did not take into account elapsed time between Precalculus and Calculus. Elapsed time may have been important, as students who passed Precalculus in high school waited an average of one year longer to take Calculus than students who passed Precalculus in college (see Figure 1).

Figure 1. Number of Years between Precalculus and Calculus for Students who passed Precalculus in High School or College

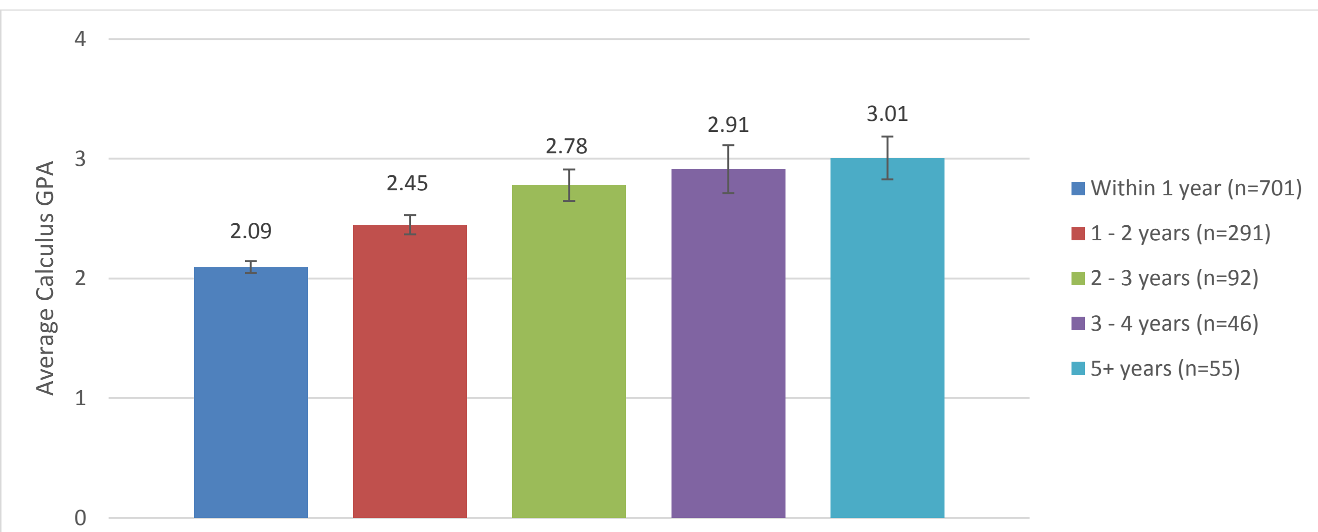


The Effects of Elapsed Time

The present study examined the relationship of Calculus grades and elapsed time between Precalculus and Calculus. We utilized a sample of 1,185 Utah students who passed Math 1050 and 1060 in the same academic year, in either high school or college, and then enrolled in Calculus in college, with no intervening math classes. We used elapsed time and enrollment type (completion of Precalculus during high school or college) to predict Calculus grades.

Results[i] showed that elapsed time was significantly related to Calculus grades and that enrollment type was not. Interestingly, the more time that elapsed between Precalculus and Calculus, the higher the students' grades in Calculus, regardless of enrollment type. Figure 2 shows the relationship between elapsed time and calculus grades.

Figure 2. Average Calculus GPA by Elapsed Time



Given the counter-intuitive nature of longer delays predicting better Calculus grades, further inquiry regarding this relationship was warranted. We used the original sample to answer two additional questions:

1. *How did the relationship between elapsed time and Calculus grades compare to relationships between other demographic and academic factors and Calculus grades?*
2. *Could the relationship between elapsed time and Calculus grades be explained by the other academic or demographic factors?*

To answer question 1, we ran simple correlations between Calculus grades and 15 demographic and academic factors.[ii] Table 1 shows the relative strength of the relationship between elapsed time and Calculus grades. It also shows that twelve of the 15 factors significantly predicted Calculus grades; three of the factors (gender, race, and age) did not. Although cumulative high school GPA, ACT math scores, and Precalculus grades had a stronger relationship with Calculus grades than elapsed time, elapsed time was a significant predictor of Calculus grades. Elapsed time was a better predictor of Calculus grades than high school Geometry, Algebra, and Pre-Algebra standardized test scores; whether College Precalculus was taken in high school or college; and number of attempts of College Precalculus.

Table 1. Simple Relationships between Calculus Grades and Other Factors

Factors	What predicts higher Calculus grades?	Strength of Relationship (Effect Size)
Gender, Race/Ethnicity, or Age	*No significant relationships*	None
College Algebra attempts	Fewer attempts	0.5%
College Trigonometry attempts	Fewer attempts	1.3%
Precalculus in high school or college	High school	1.5%
HS Pre-Algebra standardized test score	Higher scores	2.3%
HS Algebra standardized test score	Higher scores	2.8%
HS Geometry standardized test score	Higher scores	3.4%
Time between Precalculus and Calculus	**More elapsed time**	**3.7%**
Cumulative HS GPA	Higher GPAs	6.1%
ACT math score	Higher scores	6.3%
Precalculus grades	Higher scores	19.6%

*College Precalculus grades were from either high school or college enrollment.

Although Table 1shows the effect sizes of simple correlations between each factor and Calculus grades, interrelationships among these factors may confound interpretations of the simple correlations. Consequently, we wanted to know whether these interrelationships could account for the significant relationship between elapsed time and Calculus grades. For example, were students who delayed taking Calculus also older than students who took Calculus immediately after Precalculus, and if so, could age explain the better Calculus grades for those students?

When we predicted Calculus grades with all of the factors simultaneously, the relationship between elapsed time and Calculus grades did not change. [iii] This indicated that the relationship between elapsed time and Calculus grades could not be accounted for by interrelationships with any of the other factors.

Conclusion

The relationship between elapsed time and Calculus grades was unexpected and not easily explained. It is unlikely that elapsed time led to positive outcomes in and of itself. There may be other factors that can account for our findings, such as intervening courses or policies governing admittance into Calculus. Due to the importance of Calculus as a gateway to STEM degrees, future studies are needed to understand what may account for the increases in Calculus grades associated with time delays. For instance, future studies could explore time-based enrollment policies and the effects of interim activities on Calculus grades.

Endnotes

[i] Two-way fixed effects ANOVA results showed a non-significant main effect for enrollment type, $F_{(1, 1056)}$=2.061, p=.151; a significant main effect for elapsed time, $F_{(3, 1056)}$=7.243, p<.001; and a non-significant interaction effect for enrollment type by elapsed time, $F_{(3, 1056)}$=2.214, p=.085.

[ii] Factors were selected based on literature and previous research. Demographic factors such as eligibility for free and reduced lunch and special education designation were intentionally not included in the current analysis as they showed no significant relationship with grades in Precalculus.

[iii] Results from an OLS multiple regression that used all 15 factors to predict Calculus grades showed that the model was significant, $F_{(13, 195)}$, p<.001, adjusted R^2=.375. Within this model, **elapsed time was a significant independent predictor of Calculus grades, B=.443, p<.001**. Standardized beta coefficients (B) from other factors were as follows: Gender B=.133, p=.029; White B=-.108, p=.067; Age B=-.253, p=.034; Math 1050 attempts B=-.021, p=.717; Math 1060 attempts B=.08, p=.205; Precalculus in high school B=-.325, p=.003; Pre-algebra CRT B=-.092, p=.188; Algebra CRT B=.093, p=.238; Geometry CRT B=.05, p=.513; High school GPA B=.192, p=.009; ACT Math B=.031, p=.681; Precalculus grades B=.3, p<.001.

As seen in the degrees of freedom, about 80% of the students were not included in the first model. Students were not included due to incomplete data, particularly data from high school. A second model was run using data that was more complete across all participants. The second model was also significant, $F_{(6, 578)}$=37.312, p<.001, adjusted R^2=.279. Within the second model, **elapsed time was a significant predictor of Calculus grades, B=.286, p<.001**. Standardized beta coefficients (B) from other factors were as follows: Precalculus in high school B=-.139, p<.019; Geometry CRT B=.251, p=.802; ACT Math B=1.309, p=.191, Precalculus grades B=.416, p<.001; Age B=-.041, p=.472.